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MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF STANFORD UNIVERSITY

SIZE AND DISTANCE OF PROJECTION OF AN AFTER- IMAGE ON THE FIELD OF THE CLOSED EYES

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A. OCCASION FOR THE EXPERIMENT

During the Fall semester of 1910, a beginner's class in experimental psychology in Stanford University had occasion to estimate the size of an after-image of a disc 1 cm. in diameter on the field of the closed lids. The results of this off-hand estimation were varied; some thought the image exceedingly small, but a fraction of an inch in diameter, others thought the image much larger than the actual disc. This led to an attempt to see if there is any law or regularity governing the apparent size of the after-image or whether it is merely a matter of individual determination. Specifically the question called for a determination of the apparent distance of the after-image from the eye and its size on the closed field of vision, i. e., the field with the closed lids.

The only references to the subject which the writers were able to unearth were an allusion by Fechner in the *Psychophysik*, harking back to an investigation on complementary colors published in 1838, and a casual remark by Hering in an early number of his *Beiträge*. Fechner's statement runs as follows:—"Schaut man eine Lichtflamme oder irgend ein farbiges Object, was ein Nachbild zu liefern im Stande ist. aus einer grössern Entfernung als der deutlichsten Sehweite an, so wird das Nachbild im geschlossenen Auge dann kleiner zu seyn scheinen, als das Object; grösser dagegen, wenn man dieses aus kleinerer Entfernung als der deutlichsten Sehweite, anschaute. Das geschlossene Auge beurtheilt also die Grössenveränderungen, welche das Nachbild je nach der Entfernung des Objects erfährt, richtiger als das offene Auge die Veränderungen in der scheinbaren Grösse des Objects selbst. Denn die Objecte scheinen uns, vermöge einer uns zur Gewohnheit gewordenen Association des Urtheils mit der Empfindungen, bei verschiedenen, nur nicht gar zu grossen. Abständen betrachtet, immer dieselbe Grösse zu behalten; obwohl natürlich ihr Bild im Auge hiebei einen verschiedenen einnimmt. Im geschlossenen Auge vermissen wir die Umstände, welche unser Urtheil hiebei leiten, und es bleibt bloss die Empfindung des Raumes übrig, den das Bild auf der Netzhaut einnimmt; wobei ein unwillkürlicher Vergleich seiner Grösse mit der Grösse stattfindet, welche das Bild bei Betrachtung des Objects aus der deutlichsten Sehweite erlangt."¹ For Fechner therefore the size of the after-image in the field of the closed eye seemed to agree with that of the inducing object when the latter was placed at the point of clearest vision, though this

¹ *Poggendorff's Annalen*, XLIV, 1838, 524.

opinion would seem to have been an *obiter dictum* springing from general impressions. At any rate there is nothing to show that Fechner had tried to work up the matter quantitatively.

Hering's observation occurs in the midst of a criticism of Wundt's projection theory of vision, and is to the effect that the size of the after-image in the field of the closed eyes depends on the distance at which one images it.² But this again appears to be a statement based on casual observation or perhaps on the inference that the conditions affecting the size of the after-image in the open field of vision would also govern it when the field was closed. With so skilled an observer as Hering, it is well to 'go slow' in opposing opinions in matters optical; but at any rate none of the observers in the present investigation found any noticeable change in the size of the image though imagining it placed at different distances.

B. DESCRIPTION OF EXPERIMENT

Apparatus. After considerable experimenting as to form, size, color and distance of the object producing the after-image, the following arrangement was found most satisfactory. The inducing object was a 22 cm. square of red paper (shade No. 1, Bradley Educational Colored Papers), placed with its center at the level of the eyes on a sheet of gray (Bradley green gray No. 1) 52 cm. x 62 cm. The whole was tacked to a vertical wooden screen, the base of the screen being on a line parallel to and 71.12 cm. from the side of the table at which the observer was seated. To a second wooden screen like the first, two sheets of green gray paper (Bradley No. 1) 52 cm. x 62 cm. were tacked at the top only, allowing the upper sheet to be easily put out of the way. The under sheet was ruled in 5 mm. squares, every fifth line being heavy, making heavy lined 25 mm. squares. A meter stick fastened to the edge of the table between the observer and the first screen served as a scale along which the second screen was moved with its plane parallel to the plane of the first screen and at right angles to the line of vision of the observer. A headrest completed the apparatus. The room was lighted by two south windows behind the observer, and lying to his left and right. The light was kept as nearly uniform as possible.

The results noted here are from three observers, *A.*, *C.*, *L.*; *A.* and *C.* are members of the Psychology Department; *L.* is a student with considerable experience in laboratory method and in introspection. A fourth reagent took part in the investigation, but on account of visual troubles which made the development of after-images uncertain, the findings of this reagent are not entered in the tables.

Comparison and Projection of After-images

The observer was seated directly in front of the square of red paper, as close to the table as possible. The second screen was placed along the edge of the table in front of the observer, thus making a vertical wall in his face. By aid of the headrest the head was pushed forward until the nose almost touched the screen. The distance from the eye to the screen was measured; then the first or stimulus screen (with the square of red paper) was adjusted until the distance from the eye to the red square was exactly 71 cm. The second screen was then removed. This procedure was carefully followed from day

² *Beiträge zur Physiologie*, Heft 1, 638.

to day, thus keeping the distance from the eye of the observer to the screens constant and the position of the head unchanged.

Securing the Distance of Projection

The following instructions were given to the observer:—"On the signal, 'Ready,' fix the gaze and attention on the center of the red square. (Indicated by a small dot of white paint. A fixation of 10 seconds was allowed.) On the signal, 'Close eyes,' do so and note the size of the after-image on the fields of the closed lids. Then project the image on the screen of gray paper which has been placed before you. Try to project the image on the surface of the screen (not through it), at the place indicated by the dot. (A dot was placed directly on a level with the eyes on the second or projection screen at the time of adjusting the headrest. The dot assisted in holding the after-image quiet and also prevented increasing the distance between eye and screen by sideward and downward projection.) Note the size of the projected image and compare size with the image on the closed lids, using the latter as a norm. Give introspections. The judgment-terms you are to use are as follows: much less, less, doubtful, like, larger, much larger. State whether the image is clear or dim."

The procedure was then as follows: The observer developed an after-image, closed his eyes and noted the size in the darkened field. Meanwhile the experimenter had placed the second screen of gray paper in front of the observer,—in the preliminary experiments the screen was placed about 65 cm. from the eye of the observer to begin with,—who then projected his image on the gray screen and compared its size with that of the image projected on the closed field of vision. The experiment was then repeated, the projection-screen being moved nearer each time until the image on the screen was pronounced smaller than the image with the lids closed. In this series a region of like and doubtful judgments was usually passed through. In a subsequent series the time and space order were reversed. When binocular vision became difficult, as the screen approached the face, one eye was used.

Practice in developing and comparing after-images was given for several days until the observer was thoroughly familiar with the whole procedure. During this time the experimenter was able to outline roughly the distance from the eye at which the images under the two conditions of projection were pronounced 'like.' Having roughly blocked in the field, the projection screen was moved back and forth 6 or 7 cm. at a time. A set of experiments consisted in securing a series of judgments from much greater to much less, passing through an intermediate series of 'like.' Ten such series of experiments were performed with each observer. With increasing practice, there came a very considerable increase in ease in comparing the two forms of after-image, so that many judgments of larger and smaller were delivered with a feeling of complete security. One of the reagents was able to make a double comparison, i. e., after comparing the image with eyes closed and the image on the gray screen he was able to close the eyes again and make the reverse comparison. Still, for obvious reasons the comparison of images is not as easy a process as comparing outside objects, so that in giving figures of the results it seems better to indicate the region within which the images may be regarded as approximately equal rather than to figure out set distances.

C. RESULTS

The regions of fluctuating, like and doubtful judgments for the several reagents are as follows:

TABLE I

	<i>Cm.</i>	<i>Larger</i>	<i>Smaller</i>	<i>Like and Doubtful</i>
<i>C.</i>	17,8	4	3	3
	17,1	4	3	3
	16,5	2	4	4
	15,9	2	4	4
	15,3	2	6	2
<i>A.</i>	8,2	8	1	1
	7,6	5	3	2
	7,0	4	3	3
	6,4	1	3	6
	5,7	0	4	6
	5,1	0	10	0
	9,5	7	0	3
	8,9	3	0	7
<i>L.</i>	8,2	2	0	8
	7,6	3	0	7
	7,0	3	0	7
	6,4	3	0	7
	5,7	0	1	9
	5,1	0	3	7
	4,5	0	6	4

For *C.* therefore, there was a stretch of about 2 cm. lying between the distances of 15, 9 and 17.8 cm. from the cornea where he was unable to distinguish clearly or securely between the sizes of the two after-images; the corresponding values for *A.* are 2 cm. between the distances 5.7 and 7.6 cm. and for *L.* 2.5 cm. between 6.4 and 8.9 cm. But these figures differ widely from the distances of clearest vision for the several reagents.

Using Scheiner's method for determining the near-point of distinct vision, the following values were obtained as averages of 10 determinations:—

	<i>Right Eye</i>	<i>M. V.</i>	<i>Left Eye</i>	<i>M. V.</i>
<i>C.</i>	19,5	1,3	24,1	2,1
<i>A.</i>	74,9	3,1	73,3	2,1
<i>L.</i>	33,2	3,6	31,9	5,7

These figures indicate that the nearest point of clear vision does not determine the distance at which we seem to project the after-image in the field of the closed eyes or, what amounts to the same thing, in a darkened field; and the question arises: How far away is the image projected? Assuming that the apparent size of the image is governed, as in the case of the opened eyes, by the distance to which we project it, we can measure the size of the image projected on a screen and then compare the results with the figures which give the distances at which the two forms of image appeared approximately equal.

The next step of the experiment accordingly was to measure the size of the image projected on the gray paper ruled into 5 mm. squares previously mentioned, the inducing square of red paper being moved in or out with steps corresponding to those used in the first part of the work. This measurement, which was usually accomplished by comparing the upper or side lines of the image with the lines on the paper, was at first anything but an easy task; to hold the image bright and clear on the paper and at the same time measure the spaces covered by it was something requiring considerable practice.

In determining the dimensions of the projected after-image the ruled screen was moved in or out for *A.*, over a series of 20 steps: for *C.* and *L.* the steps were 18 and 15 respectively. From these series we shall select here only those which, in the first experiment, correspond to the region where the difference in size of the after-image in the light and dark fields was not noticeable, i.e., the region where they seemed about equal. These regions and the length of the side of the corresponding after-image are given in mm. in the following tables:

	<i>C.</i>	<i>A.</i>	<i>L.</i>
<i>Region of equality</i>	159—178	57—76	39—64
<i>Side of after-image</i> (av. of 10).....	55—63	25—30	20—25
<i>M. V. of readings</i>	2,5 2,3	2,4 2,6	2,2 1,6
<i>Geometric projection of after-image at above distances</i>	49—55	18—24	12—20

We find then very considerable differences in the size of the after-images in the darkened field; but we are not prepared to say on what this difference depends. Noticeable is the difference between the apparent size of the image and its size calculated on the basis of the dimensions of the schematic eye. And in every case the observed image is larger than the geometrical projection of the retinal image. Broadly speaking, this difference increases absolutely and so of course relatively with decreasing distance of projection. Certain observations, made during the course of the investigation, may later be of value in working out the factors determining the size of the image in the darkened field. In the first place, the readings and measurements were practically alike for both eyes and for one eye. In equating the size of the two forms of after-image, series for each eye supplemented those for both eyes as given above, and the results always fell within the limits of the figures for both eyes.

Next, convergence seemed to play no important rôle in determining the size of the image or at least not a prominent rôle. Hering states that neither convergence nor accommodation plays any part at all.

One of the writers (*A.*) thought he noted the effect of convergence, but until he acquires somewhat of the *Virtuosität* in the control of the eye-muscles which Hering seems to enjoy, he prefers not to press the matter.